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ABSTRACT
Interaction designers involved in design of feedback motivating electricity conservation aiming to change people's behavior in the home must handle the dilemma between perceived affordance and perceived annoyance. This paper reports findings from an explorative, qualitative study on interaction concepts for online feedback on electricity consumption in private households. Working together with eight families, we found that the difference between perceived affordance and perceived annoyance depends on when, where, and how much information is given, regardless of difference in values and attitudes towards electricity consumption in general. Combining theory of self-determination and ecological psychology with results from co-operation with eight families allows us to present concepts for design of what we have termed ecological feedback.

Author Keywords
Feedback, electricity conservation, sustainable interaction design, domestic settings, self-determination theory, ecological psychology.

Did you feel you were tricked by the future you picked? Well come on down. All the rules don't apply when you are high in the sky so come on down…". (Peter Gabriel, Down to Earth lyrics, Soundtrack from Wall-e).

INTRODUCTION

Electricity consumption in private households makes up a significant part of the total consumption of electricity both in industrial and developing countries [28]. In Denmark, where this research was conducted, households stand for 1/3 of the total electricity consumption [11]. Initiatives toward electricity savings in private households comprise technological development of online feedback and automatic controls, and behaviour change through feedback and information service, as well as the development of low energy appliances for households, control management and automatization. In Denmark it is estimated that use and innovation of present and future control systems can reduce electricity consumption with up to 30% (www.danskenergi.dk). Effort is put into developing intelligent houses. Equally effort is put into campaigns for motivating households to change to electricity-conscious behavior. Human behavior is a grey area – difficult to measure but central for the consumption: it is estimated that households can make a 26-33% savings on their electricity consumption by behavioral change only [26].

This is, in a nutshell, the challenge dealt with in the presented research in this paper: making households' contribute to electricity savings. The initial quote is from the soundtrack of the Disney™ movie Wall-e: a cartoon story about how all humans have left the earth, living on luxury space ships, while waiting for robots like Wall-e to clean up the earth. It is a story for both kids and adults with the very clear point of taking responsibility and action – coming down to earth. Technical solutions cannot solve the environmental crisis if not supported by environmental behavior. The cartoon and Peter Gabriel's lyrics point out the challenge of making people take action: "all the rules don't apply when you are high in the sky". Metaphorically speaking we have worked with how to bring electricity savings to the ground i) by taking up the challenge of behavioral change via feedback motivated electricity conservation and ii) by taking up the challenge of working from the ground via user-driven innovation as a method.

In this paper we present first, our case of electricity conservation through motivated feedback and related work within this area. Second, we present a theoretical perspective, ecological psychology, supporting our effort of putting the home in the foreground of our analysis and self-determination theory, supporting our effort of motivating electricity saving. Third, we present our methods for user-driven innovation. Our results – user-driven points, are summarized in the sentence "we say where, we say how

much, and we say how" and worked into three central concepts for feedback-motivated electricity consumption in private households. The concepts are exemplified in an interface design for a medium screen solution – an example of how to bring invisible daily household consumption down to ground. We conclude by summarizing the findings in the concept of 'ecological feedback'.

ELECTRICITY CONSERVATION IN PRIVATE HOUSEHOLDS THROUGH MOTIVATING FEEDBACK

The research we present here was conducted as part of a larger project – the FEEDBACK-project[1] – where electricity providers, software enterprises within the mobile and smart house market, and researchers within Consumer Behavior and Interaction Design work together on the analysis, design, implementation and test of on-line feedback to private households via fibre-optic broadband. In Denmark electricity providers are establishing fibre-optic broadband to private households opening the possibility of displaying measurements online. This provides new opportunities for communication between power providers and customers in the form of on-line and even disaggregated end-use feedback, which has so far been categorized as *"relatively expensive and complicated to supply"* [7]. In the FEEDBACK-project these authors dealt with challenges of making such feedback adequate and motivating. Our strategy seeks to meet calls from consumer behavior researchers claiming that *"much information about energy use ... is presented in dull, uninteresting formats"* [6]. There is also a call for *"user-friendly displays ... as part of any meter specification"* [7] since *'Consumers who have their supply metered in the standard way are unlikely to consult their meter: it will probably be hidden away and difficult to understand"* [8]. In general there is an acknowledged lack of knowledge about how to obtain fit between the form of feedback and the context of its use: *"Achieving energy conservation is a twofold challenge, partly technical and partly human... Unless adopted by a significant segment of consumers, the impact of technical innovations will be negligible"* [6]. As summed up by Wood and Newborough [28] in a review paper *"it is unclear how best to achieve feedback in the home and several research questions emerge. For example, how frequently to feedback the information; in what format to present the feedback (e.g. as numbers, graphics, energy/cost/C02 data); and whether the feedback should be displayed centrally or at the points of end use"* [28].

We were encouraged by other researchers in our field of Human Computer Interaction [12, 13, 29] pointing out that Interaction Design has much to offer in relation to this research question, and in general to the area which has so far been termed 'Sustainable Interaction Design' (SID) [4].

[1] http://feedback.noe.dk/

Feedback, when perceived, enforces learning as well as habit formation [26]. Studies from the 1970s reveal that feedback about electricity consumption has measurable effect [7]. However, it is also stated that *"the most effective feedback is that which more immediately follows an action"* [28]. A review sums up the savings of direct feedback (from the meter) to 5-15% [7] and first experiments with feedback disaggregated by end-use has proved a total decrease by 18% in power-consumption [25]. In contrast energy bills, information campaigns and other frequent or infrequent written feedback, indirect feedback, have a savings range from 0-10% [7].

RELATED WORK

Studies of household electricity consumption points to households being units of varying stability, values and habits. Background variables such as family type, income, education, and the size of the house explain 40% or more of variations in electricity consumption in private households. In order to understand the rest of the variation, attitudes towards electricity consumption are relevant as a basis for defining family types like 'the energy conscious', 'the busy' and 'the careless' [11]. The eight families in this study have been selected through a screening procedure working with the above variables and typologies combined with selecting criteria for innovativeness [14].

However, studies also show that feedback for motivating electricity conservation is a quite complex task where personal values, attitudes and social norms regarding environmental behavior play a minor role only compared to structural conditions, such as home size and family size. In other words: green attitudes and electricity consumption are not closely related. One of the reasons for this is the invisible nature of electricity consumption, which places it out of focus of its users. Additionally, a pronounced reduction in electricity consumption may compromise comfort in the everyday life and may have a disturbing effect on daily routines [18]. As elaborated by Kuehn [16] electricity consumption is a direct or indirect consequence of other fields of consumption. This, and the invisible nature of electricity, means that its consumption is often an un-reflected part of everyday life [16].

Naturally, making electricity consumption visible has significant influence, and as presented in the introduction, experiences with electronic and on-line feedback has measurable effects. There are experiments with electricity meters, monitors and PC-applications [7, 28]. On the basis of a review on metering, billing, and direct displays Darby concludes that *"Monitors would be most useful if they showed instantaneous usage, expenditure and historic feedback as a minimum, with the potential for displaying information in microgeneration, tariffs and carbon emissions"* [7]. However, consumer behavior research related to motivation psychology stresses that making electricity consumption visible is not enough and calls for empowerment of consumers. It is pointed out that *"limited*

abilities and restricted opportunities ... make it difficult even for highly motivated individual to do anything radical to improve the sustainability of their lifestyle" [24]. Empowerment involves *competence, relatedness, and autonomy* [24]. Similar results are found in recent design experiments like '222b Lee High Road' where RED (http://www.reduk.net/) worked on how to strengthen policy towards domestic energy use starting from a householder centered design approach. Design leads from this work are: the importance of making energy visible, design for control, appealing to multiple motivations and collaboration [17].

Generally, the literature can be read as a warning of not underestimating the complexity of human behavior in design of feedback. As stressed by [6] often used and too simple theories on conservation behavior are 'the attitude model' and 'the rational-economic model: *"The attitude model assumes that conservation behavior will follow automatically from favorable attitude towards conservation. The rational-economic model assumes that people will perform conservation behaviors that are economically advantageous"* [6].

THEORETICAL PERSPECTIVES

In our research we aim to work with the above presented complexity of feedback at home by making use of insights gained in self-determination theory related to motivation and theory on ecological psychology related to the environment of home.

A theoretical perspective on motivation

"Informational feedback" is a term coined by Deci & Ryan's in their model of self-determined and non-self-determined behavior [9, 20]. In broad terms Deci & Ryan assume that motivation in the outset is non-self-determined and depending on information input, the environment and the personal need structure, physiologically and in memory, while in the state of self-determination the motivation is coming from within, because the externally enforced motives have been internalized. Deci & Ryan operates with five stages of regulation ranging from 'non-regulation' - 'external regulation'- 'introjected regulation' – 'regulation through identifications' – 'integrated regulations'. In relation to utility feedback 'external regulation' refers to the situation going from experiencing initiating events as pressure to perform accordingly and not experiencing a real sense of choice, to gradually getting more to grips with the control oneself is the most interesting. What Deci & Ryan find pushes an individual in this direction is positive feedback, which they describe as 'informational'. An informational event is characterized by: "a choice, in other words, the absence of unnecessary controls, so that one can experience a sense of self-determination. Second, there must be some type of effectance-relevant information via-a-vis one's performance on an optimally challenging activity. And finally, if the event somehow conflicts with a person's needs or feelings, this implicit conflict must be acknowledged" [20]. Furthermore Deci & Ryan stress relatedness to be an important part of informational feedback: "The informational aspect of positive feedback affirms people's self-determined competence. The controlling aspect of positive feedback controls people's behavior by capitalizing on their need to be liked. When people want praise, praise can be used to pressure them toward specific outcome" [20]. In a chapter devoted to work situations Deci & Ryan point out three principles as constituting positive intervention:

- minimal sufficient control,
- informational feedback and
- acknowledging conflicting feelings.

A theoretical perspective on home

Ecological psychology, as defined by Barker [1] is concerned with the ecological environment of molar human behavior. The term ecology – meaning "home" or "homeland" in Greek, refers in ecological psychology to the structure, dynamics and content of the behavior of habitats. Ecological psychology works with the inside-outside problem: the outside ecological environment and the inside psychological environment (or life space) [1]. Additionally, without reference to Barker but based on J.J. Gibson's work and a philosophical approach, Reed contributes to the field of ecological psychology especially with the use of affordances as an ecology for psychology [19]. We use ecological psychology as a perspective in our work with the complexity of feedback. Feedback is a complex interaction of environment and people, where behavior cannot be predicted by simple theories of stimuli. As stated by Reed: *"agents make things happen, they make their way in the world, or, in the present jargon, they encounter their environment. These agents encountering this environment are flesh and blood, nerves, muscle, and gut. Hormones can change these agents' state of readiness and so can external stimulation. But the actions of these agents are not the effect of just these, or any, such causes. Their actions are part of a stream of regulatory activities that are typically self-initiated and modified and regulated by both internal and external factors"* [19].

In our work with ecological psychology we have used the central ecological units:

- Behavior episodes: a unit of behavior and situation in the life of an individual person, a stream of action obvious and easy to see [2]
- Behavior objects: the standing patterns of behavior and part of the non-psychological milieu to which behavior is anchored, also called behavior-milieu synomorphs [2].
- Behavior settings: perceptually segregated units of extra-individual behavior. They are community areas, which individuals enter, and in which they behave in

accordance with forces that produce the characteristic behavior pattern [2].

- Affordances: opportunities for action that can be used and can motivate action, yet they do not and cannot cause behavior [19].

Theoretical contribution

We have used the ecological units to guide our interpretation of the environment of home. And we have used especially Deci and Ryan's principles for positive intervention to understand the families' preferences in relation to where, when, and how much feedback they will appreciated and allow in their everyday life at home.

In this process we have come to understand, what we call 'ecological feedback'. Ecological feedback is a concept in between thinking and not thinking, in between affordance and annoyance. We are yet to get a more firm grasp on this concept which we at this stage define as feedback which technically is ambient, in that it forms a backdrop of the habits related to consumption of electricity, but which psychologically is self-motivating in that it reminds at a glance in situations where a reminder is accepted.

In the discussion of the paper we elaborate on this perspective on the basis of empirical findings.

METHODS AND DESIGN PROCESS

The participatory design practice, which we have employed in our research project has recently been inspired by the work of Thomke & von Hippel on user-driven innovation [22]. Their ideas and key techniques focus on 'acting with technology' by creating design artifacts and design events, which makes users innovate, in cases, when you as a designer need to get access to the sticky and tacit information of use context. The added value, compared to ethnographic studies, is insight into user trajectories of operation, preferences and values, and in best cases also user generated ideas, within a short time-span.

The importance of involving users in cases like this is emphasized by von Hippel's notion of 'sticky information': information related to behavior stick to the context and is hard, maybe impossible to express verbally, and at least costly to move from the site where the information was generated [27]. Another reason is the need to find the balance between tradition and transcendence [10], so that the environment on the one hand stays familiar to the users and on the other hand develops. As emphasized by Bell, Blythe, and Sengers [3] in relation to design for domestic settings de-familiarization is central: "*because the home is so familiar, it is necessary to make it strange, or de-familiarize it, in order to open its design space"* [3]. This implies designers to evoke users towards de-familiarization. It is a bootstrapping-challenge to request people to design for something, which to them is silent, transparent and mundane such as everyday electricity conservation. In our design process this has come out through a facilitated process with artifacts as drivers for articulation, cooperation and innovation.

The home innovation process in the FEEDBACK-project was organized in the following steps:

1. *Tune in*: tune the households in on the subject of electricity consumption
2. *Focus*: households focusing on their electricity consumption
3. *Explore*: households exploring concepts for on-line feedback on electricity consumption
4. *Innovate*: households making innovations on feedback for on-line electricity consumption
5. *Design*: Interaction designer bringing household innovations to form
6. *Evaluate*: households evaluating the design outcome.

All steps were planned and guided by the authors. Step one, two, three, and six took place in the families homes. Step four and five took place at the University Below we describe this 'household-innovation' in further detail, with emphasis on what was shared reactions by all participating households.

Tune in: the energy power game

In order to 'tune-in' on the subject of electricity consumption, and to engage the whole family (also children) in conversation, we created a card-game, which we called "EnergyPower". It was a game with 52 cards with different pictures of electrical appliances (toasters, lamps, TVs, computers, etc.) and among these five trumps being pictures of things, which used no electricity at all (candles, oil lamps, etc.). The cards were distributed among the family members. All the participants, one at a time, would throw a card on the table, and the one with the least electricityconsuming appliance (the most "EnergyPower") would take the points. Playing "EnergyPower" required the families to reflect on what they actually knew about electricity use both in general and in relation to concrete appliances at the cards and in their own household. Within app. 15 minutes they became 'tuned in' on the subject and wanted to learn more.

Focus: the photo-tour

After the card game the families were given a Polaroid-camera and asked to take 10 photographs of places in their home, where they would like more information about their electricity consumption. Most families split up in two teams taking 5 pol-photos each. After the photo-tour the family members returned to the dinner table. They took turns presenting the photographs and jutting down, on the pol-photo, one sentence explaining what information they were seeking or thinking of when taking the photo. The exercise was challenging in that it forced the families to reflect on their habits and needs, but also to come up with ideas for

information about electricity consumption. The interaction taking place on the dinner table was videotaped.

Finally, the authors asked for permission to take a photo of the family members on the location where they where most wanted information about their electricity consumption. Four families chose the house computer, two families chose the refrigerator, and two families chose the meter in the utility room.

Figure 1. An example of polaroid-photos with written questions. Top-left: "consumption in five minutes for a hairdryer?", Top-right: "Does a flat-screen use more or less power than the good old computer-screens? The total consumption for the PC as a minutes price". Low-left: "how big is the electricity consumption for one year in total?", Low-right: "What is the price for heating 110 litres of water?"..

Experience: mock-up experiments

On the basis of analysis of the above materials [14] we designed five mock-ups, based on five identified concepts for feedback on electricity consumption.

- *The concept of 'on-off'* for reminding. This was put to form in a display with 10 appliances and a notification on whether they were on (red) or off (green).
- *The concept of 'speed'* for observing. This was put into form in a speedometer (inspiration from cars) displaying the current speed of electricity consumption in the household.
- *The concept of 'quantity'* for observing. This was put into form in the design of a) a scheme displaying the amount of washing during a week supplied with a note on the cost of different types of washings and b) a book displaying the use of Playstation ™ or pc during a week (designed especially for the kids).
- *The concept of 'log'*. This was carried out via use of the local electricity company's existing website giving users access to logging registrations from their meters.
- *The concept of 'status'*. This was carried out via use of a) the Danish Electricity Funds website giving users access to register their appliances and get a norm-status on these and b) power meters which the households could use to measure the consumption of appliances.

Each family received 2-4 mock-ups, distributed to best match what they had themselves presented as needs and wishes during our initial visit and experimented for one week. A person (the father, the mother, the one who returned first to the house every day, etc.) was appointed be responsible for changing 'screens' in the mock-ups, testing if they were still in their place, etc.

Innovate: design workshop

With these experiences fresh in mind the families were eager to contribute with their own ideas. At a workshop they first evaluated the above mock-ups and second worked in groups on design of their own mock-ups for feedback. Three mock-ups were developed by the families:

1. A mock-up designed for a monitor to be placed in the hallway or on Text TV showing i) what is on and what is off, ii) consumption related to a national norm for the type of household and iii) consumption related to the households own norm previous years. It was emphasized that the design should be "VERY simple" (capitals in original), easy to place a central place in the household, functional emphasizing "it can be turned off". Combining the design with information on other central consumptions like water, heating and garbage for the household was pointed out as an advantage.
2. A mock-up designed for a mobile monitor to be placed where-ever in the house and displaying the consumption in a barometer with the colours red, yellow and green: the left side of the barometer displays the current status of the consumption this year and the right side of the barometer displays the consumption at the same time but last year, i.e. the left side of the barometer is to be compared with the right side. Competition
3. was emphasized by the innovators of this mock-up. The left side being compared constantly to the right side was argued as a constant competition for the household against the household. The fact that the monitor was mobile was argued as a possibility to bring it to the neighbor or friend to compete on current consumption.
4. A mock-up designed for a fridge-monitor presenting I) what is on and what is off in the household, II) the consumption of every room in the house and III) the total consumption and VI) the current impact displayed with an arrow pointing at green, yellow or red.

UTILITY FEEDBACK IN THE FEEDBACK-PROJECT

Already after the first home visit we realized that the generally used typologies for households in relation to electricity consumption [11] were more aspects of each family's preferences and behavior, than labels by which to

separate family types. Being, busy, being economic, being concerned about the environment was part of all eight families values but was ranked differently as criteria for behavior. What all families shared, however, was an interest in knowing more about their actual consumption, if only the information was given timely and adequate. We have summarized our findings concerning the preferences expressed unanimously by all eight families in one sentence: *'we say where, we say when and we say how much'*. In the following we try to relate this sentence to motivational and ecological psychological theory in order to establish a theoretical underpinning as to why self-determination, location and situation is fundamental, when the families express their preferences, in words as well as in design of mock ups.

We say where

The issue of location in the home was at the forefront at all times. Feedback on electricity consumption is allowed in some places at home only. Four *behavior settings* were pointed out by the eight families:

- The office and the computer is where household accounting, information search, shopping and also play takes place, a setting of conscious awareness of the interaction.
- The kitchen and the refrigerator is a location of passive awareness, where at a glance information is frequently allowed to disturb what other activity is transpiring in the kitchen.
- The utility room and the meter is a tacit part of the environment, which has to be given a conscious interface in order to interrupt and catch attention.
- The hallway outgoing doorstep is where you recollect your memory: keys, drivers licence, money etc etc and also where you go through the state of the house: windows closed, stove disconnected etc. etc.

These expressions compli with Barker's theory of behavioural settings as perceptually segregated units of extra-individual behavior. Community areas, which individuals enter, and in which they behave in accordance with forces that produce the characteristic behavior pattern, which is what creates the homely feeling of knowing what can happen here.

Additionally, the following *behavior objects* were highlighted as central object for the families in relation to electricity consumption: the meter, the refrigerator, the computer, the Playstation™, the washing machine. The families would accept to receive feedback and work on consumption cut-down on the selected objects.

We say when

We were alerted to the importance of the situation, when we during our first visit suggested that information might be presented at the TV, maybe in the evening, when sitting in the sofa, and all families rejected this idea vividly. Also in the very first home we visited, the teenage daughter immediately suggested that information should be next to the outdoor, and checking it should turn into a habit like checking for keys. And the portable monitor (family mock-up number two) came into being because a group of male designers wanted to brag about their supposing sustainable behavior and economic gain to the their neighbors when in the mood for this type of conversation.

Five central *behavior episodes* were perceived as central to electricity consumption: washing, cooking, leaving the house, computer or Playstation™ gaming, replacement of appliances and white goods, reading the meter, and going through the electricity bill.

The analysis revealed however also a need to dig deeper into especially behavior episodes. The episode of washing, as an example, turned out to be complex and containing more need for behavior insight than on families' choices of washing programs. Washing is an episode connected to several other episodes and the need to make these episodes go hand in hand often result in behavior which is not economic or environmental rational but rational in relation to the everyday life of the ecology of home and family life. For example, washing at night is good for the environment but the process of hanging laundry to a clothes-line fits badly to busy family morning where lunch boxes are prepared and time is short. Another example is the Playstation™ , which parents bring up as a possible solution for conservation but at the same time comments *"but we won't tell him to play less, will we"*. More research into behavior episodes will be a central focus in our future research.

We say how much

When confronted with our initial mock ups and later in their own designs, simplicity and at a glance transparency was the highest priority, apart from the decision mode when choosing new products. Here the families kept wanted more information, but also here it should by given in the form of simple labeling, preferably sticking to the appliances.

Four types of information for *affording* motivated electricity conservation came out as clear: reminding (e.g. remember to turn-off the light), observing (e.g. observing and being on track with the consumption), relating (e.g. relating the households consumption to general norms), decision-making (e.g. support on which washing machine to buy or when to replace the old fridge with a new one).

We call the type of feedback, which fits patterns of behavior of an ecology (vs. designing for stimuli of the individual) 'ecological feedback'. Ecological feedback is a feedback, which motivates electricity conservation with *the right information, at the right time and at the right place*. Ecological feedback is feedback, which technically is ambient, in that it forms a backdrop of the habits related to consumption of electricity, but which psychologically is

self-motivating in that it reminds at a glance in situations where a reminder is accepted.

Concepts and design example

In the FEEDBACK-project, three concepts are coined as central on the basis of the above analytic results:

- *Speed* - visualizes the current invisible consumption. Several of the families, both adults and teenagers, remembered their joy of watching old meters spin fast or slow according to the consumption now replaced with digital numbers.
- *Remind*: central to the concept of reminding is that it visualizes an overview of the on/off status on central appliances in the household. The on/off status explain the speed when put next to each other.
- *Compare* - central to the concept of comparing is that it relates consumption to a norm or previous consumption or relates appliances to each other and thereby prompting changing and buying appliances and white goods. Comparing is a central basis for the families' acceptance or fight against the consumption of electricity in the household. Consequently, national guidelines and saving objectives are crucial for understanding whether a household consumption is high or low.

Interaction based on these three concepts has been designed for a medium screen solution to be placed at fix points in households at the choice of the individual family. The final outcome (a result of several sketches and dialogues with software developers) is presented in the figures two, three, and four: To make the display nice and decorative the background changes twice a day from day to night and vice versa. A clock adds functionality and invites to also perceive actual consumption. The clock offers a combination of feedback and time providing a sense of the rhythm of consumption – becoming aware of when the household is 'speeding' or 'crossing the norm.'

Figure 2: Visualizing speed, comparing and remembering.

Speed is visualized with a pellet drifting from side to side in a tempo matching current measure of consumption; if the speed of the consumption is fast the pellet moves fast, if low it moves slowly. The text to the 'speed-bar' says: "Consumption right now: xx W", i.e. provides an accurate measurement of the current consumption.

Comparing is visualized in a bar displaying the total consumption since midnight *compared* to a norm. The bar is filled during the day. The red line is the norm (as default previous consumption minus 10 % savings). The text to the bar says "since 00:00 xx kWh" and "Expected today: xx kWh", i.e. provides an accurate measurement of the total consumption. A button labeled "Details" opens a window with information of the consumption per week, month and year (figure three). The details are displayed on graphs making it easy to compare. A red line shows the households goal savings.

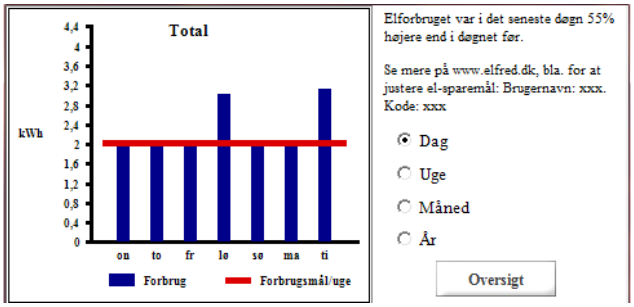

Figure 3: details of the total consumption.

Remembering is visualized very similar to the first mock-up (figure two) as a list of appliances and their on/off status. A touch on an appliance in the list opens a new window with information on the use of the appliance for the day, week, month and year (figure four). A hot-line phone number and a "See more on www.elfred.dk"-link connects to a website with details on the household consumption, advice on how to bring down the consumption, possibility of adjusting the goal for savings (the red line displayed in the feedback-application), and links to a website supporting decision-making made by the Danish Electricity Conservation Fund (http://www.selvtjek.sparel.dk/).

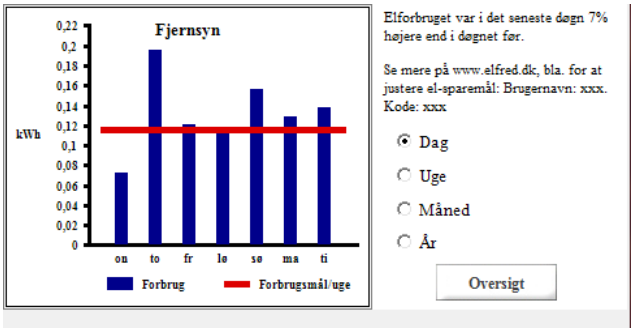

Figure 4: Details of the consumption on selected appliances

We presented a mock up of the resulting design to the eight innovating families in their homes on a laptop with an installed exe where buttons could be clicked, windows opened and the pellet was moving. Reactions were primarily positive. Negative reactions were on the size of

the text which made it difficult for some to read. In our visit the families expressed a wish to stay in contact and continue their participation in the project.

Measurements on the impact on electricity consumption will be conducted during the following test period.

UTILITY FEEDBACK AT HOME IN GENERAL

A central finding in our study is that it is the interaction between information, location, situation, and media, which the families experience as a whole and central for the feedback. We can narrow down *situations* to two types, which the families were in, when they were seeking or receiving information on their electricity consumption:

- Action situations: central in these situations is that information can be received 'at a glance' and trick action.
- Planning situations: central in these situations is that information provides a ground for status at various levels (consumption during the day, week, moth or year) and planning-support (support for decision-making e.g. when buying new appliances).

Behavioral change towards electricity savings request for frequent reminding but when, where, and how much calls for a design balancing between affordance and annoyance, between thinking and not thinking, between transparent and reflective. Finding this balance, the goal of an appropriate rythm between being transparent and reflective as called for by Bolter and Gromala [5], is indeed a challenge which eliminates web-design (a pull-technology) and SMS and e-mail notifications (push-technology). In the FEEDBACK-project this design challenge have resulted in a design for a medium screen placed at central locations in the home (the kitchen or the entrance) combined with a website.

We emphasize, that designing interfaces for motivating feedback calls for 'ecological feedback'. That is feedback, which motivates electricity conservation with *the right information, at the right time and at the right place,* i.e. working with the derived user driven points: we say when, we say where, we say how much. Ecological feedback forms a backdrop of the habits related to consumption of electricity by being transparent but which psychologically is self-motivating by being reflective in the reminding at a glance in situations where a reminder is accepted.

CONCLUSIONS

As presented by others within the field of sustainable design, acknowledging the complexity of sustainability is central. Stegall writes: "*The crisis of sustainability is more than simply an issue of poor technology; it has emerged as an extremely complex sociological dilemma, where the lifestyle that we have adopted is rapidly eroding our ability to survive. It is obvious, then, that to play a profound role in making sustainability a reality, one must persuade the general public to adopt sustainable behavior. The role of the designer in developing a sustainable society is not simply to create 'sustainable products,' but rather to envision products, processes, and services that encourage widespread sustainable behavior* [21].

In the FEEDBACK-project, and in this paper, we have worked on envisioning products, processes, and services that encourage sustainable behavior in relation to electricity conservation at home: We have presented methods and processes for engaging end-users in sustainable interaction design. We have presented user-driven points from this process and have on this basis envisioned concepts for feedback motivated electricity consumption exemplified in a user interface for a medium screen solution. And we have introduced theoretical perspectives for understanding motivation and the environment of home and on the basis of these perspective and our empirical findings we have introduced central key understandings and concepts for what we have termed 'ecological feedback'.

Based on Barker's ecological psychology, we have in our empirical material identified ecological units for feedback at home. On the one hand these units give clear directions for locations and situations to design for and not least for further research: Following Barker, further studies of these ecological units of electricity consumption can predict aspects of behavior since attributes of behavior are found to vary less across individuals within settings than across settings [1].

On the other hand the results of this study add to the complexity of the ecology of electricity conservation in households which we have aimed to understand and present with use of Deci and Ryan's self-determination theory [9, 20] emphasizing a need to be in control at home, and consequently, to decide *where, when and how much* feedback.

We call feedback, which fits patterns of behavior in an ecology (vs. designing for stimuli of the individual) 'ecological feedback'. That is feedback, which motivates electricity conservation with *the right information, at the right time and at the right place*. Ecological feedback forms a backdrop of the habits related to consumption of electricity by being transparent but at the same time psychologically self-motivating by being reflective in the reminding at a glance in situations where a reminder is accepted. Designing interfaces for feedback motivated electricity conservation at home is a balance between affordance and annoyance, thinking and not thinking, transparent and reflective. Finding this balance, the appropriate rhythm, is the real design challenge.

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